CHAPTER 17

Jack, Batt, and Pack: Powering and Packaging Your Hacked Toy

You will need:

- The electronic toy or radio from the previous experiments.
- A battery-powered mini-amplifier.
- Some hookup wire.
- One or more jacks for external audio connection.
- Some 1 kOhm resistors.
- A battery holder (if appropriate—see text).
- A box of some kind to house your circuit.
- Soldering iron, solder, and hand tools.

It's almost time to "close" your first hack, as they say in the O.R., but let's look at a few final modifications before Frank rises from the slab.

JACKS

Beyond retuning the clock and finding some musically viable almost-shorts, the most significant change you can make to a toy is replacing the little speaker with a big one, thereby confirming the Second Law of the Avant-Garde (introduced in Chapter 7) with increased loudness. A telephone tap coil resting on the little speaker is one approach, as discussed already. But if your circuit is *never* going to be played by saliva-drenched fingers it's safe to try a wired connection directly to an amplifier—a bit more preparation work than slapping the coil down, but ultimately cheaper and faster to patch together in performance.

By adding a jack to connect the circuit to an external amp and decent-size loudspeaker you not only make the sound much louder, which lets you hear more detail, but you will also hear low frequency components that aren't audible through the tiny, parent-friendly speakers inside most toys (and sometimes higher frequencies as well). It's easy to do:

1. Find the wires leading from the circuit board to the speaker.
2. De-solder them from the speaker terminals or cut them as close to the speaker as possible.

3. Solder these two wires to a female jack of your choice; usually it doesn't matter which wire goes to which terminal, but you must always have one wire going to the shield/sleeve connector and one to the hot/tip connector.
4. Plug it into a decent sound system and listen. Start at a low volume setting, since the output of a toy can be surprisingly loud. If there's lots of hum, reverse the hot and ground connection at the jack. If there's no sound at all, check your soldering. You may find that the raw sound is too much—too noisy or abrasive, too much extreme high or low—but that's where the equalization on a mixer, amp or graphic EQ "stomp box" can help you carve the sound you want out of the toy's raw material.

Let me repeat:

DO NOT ATTEMPT THIS MODIFICATION ON A CIRCUIT THAT WILL BE MAKING INTIMATE ELECTRICAL CONTACT WITH YOUR BODY (SUCH AS THE WET-FINGERS RADIO).

As long as you're adding one jack, why don't you see if there are any other interesting signals running around the circuit board yet unheard?

1. Solder a wire from the shield/ground connection on a jack to the place on the circuit board where the "–" terminal of the battery connects, or to the shield/ground terminal on the main output jack, if you've added one already. Use stranded wire if at all possible—less strain on the connections at either end, and easier to pack into the toy's case.
2. Solder another wire to the hot tab of the jack and strip and tin the other end.
3. Solder a 1 kOhm resistor to the tinned end of the wire.
4. Plug a cord between the jack and a battery-powered amplifier.
5. Turn the volume up just a little bit. Poke the free end of the resistor around the circuit board and listen to the different sounds (see Figure 17.1). Adjust the volume as needed. Sometimes you can find very odd noises that seem completely unrelated to the basic sound of the toy. Hold on to the body of the resistor, rather than the bare wire, to minimize hum.
6. When you find a place you like, solder down the free end of the resistor. Wrap the bare wire and resistor lead in electrical tape to prevent shorts (you can shorten the resistor leads prior to soldering to minimize the amount of bare wire running around your circuit, itching for a short circuit).
7. If you wish, add another jack and repeat the process, discovering and decanting hidden sounds. Or add a multi-position switch (such as a rotary switch or our homemade tilt-switch) to select among different circuit points to connect to a single jack.

If you get sound when one or the other of your jacks are connected to the amplifier/mixer, but not when you combine two or more, you have probably unintentionally crossed your grounds. De-solder one of the two incompatible jacks from its

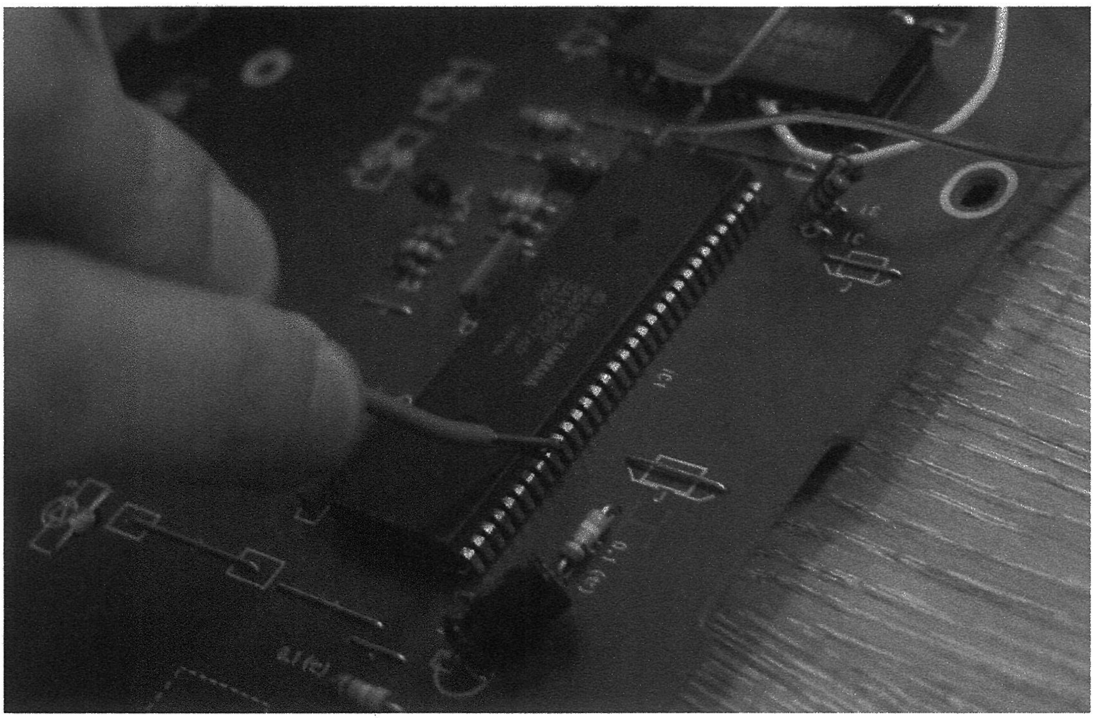


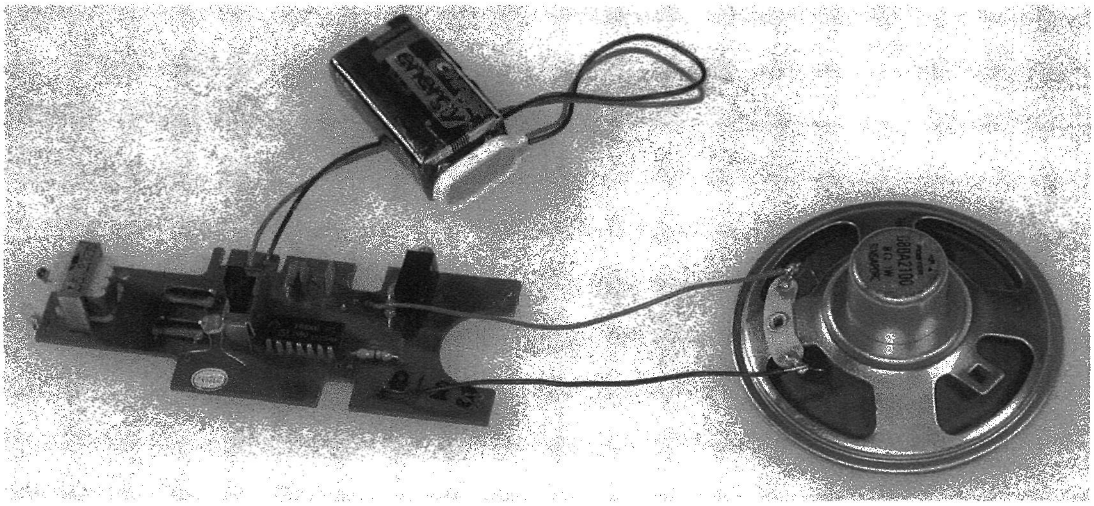
Figure 17.1 Phil Archer hunting for interesting sounds.

wires (the speaker jack, if used, is the first choice) and swap the "hot" and "ground" connections.

CUT-OUT JACKS

You may have noticed that most audio devices with a built-in speaker and a jack for headphones will switch off the speaker automatically when the headphone plug is inserted. This is accomplished with what is known as a "cut-out jack," which basically combines the functions of an audio jack and a switch, and can be purchased at almost any retailer carrying electronic connectors. The jack's terminals will be designated "tip" or "hot," "sleeve" or "ground," and "normally closed" (NC—like the switches we discussed in the previous chapter). These designations might be printed on the jack's packaging (if you buy them at Radio Shack, for example), provided in the retailer's catalog or Web site, or you might have to decode them using your multimeter in the Ohms setting. You wire it as shown in Figure 17.2.

1. Solder a wire between the jack's ground lug and the circuit ground, in parallel to the speaker's ground connection (do not disconnect the speaker ground); or you can cut the ground wire in the middle and solder *both* ends of the cut to the ground lug on the jack (as shown in Figure 17.2).



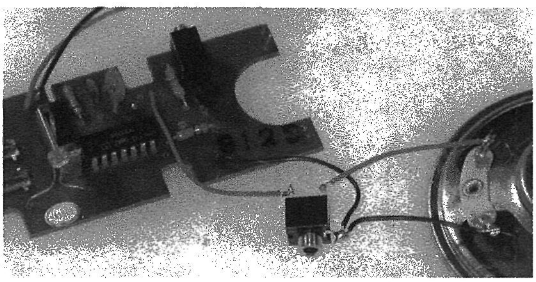


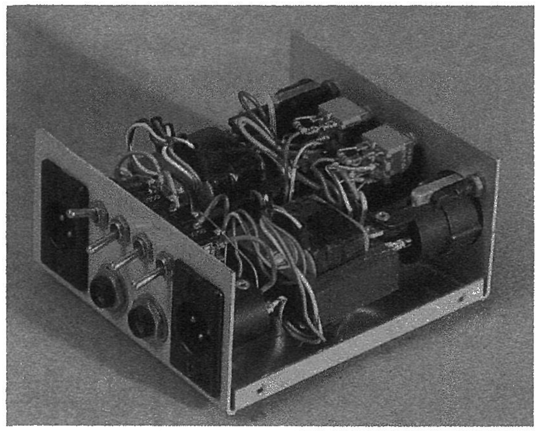
Figure 17.2
Wiring a cut-out jack.

2. De-solder the wire from the speaker's hot terminal and solder it instead to the jack's tip/hot.
3. Solder a new wire from the speaker's hot terminal to the NC terminal on the jack.

Turn on the circuit. You should hear the sound through the built-in speaker as usual. Now plug a cord from the cut-out jack to your amplifier—the speaker should shut off while the signal passes to your amp through the patch cord. If not, check your wiring logic and soldering joints—it's easy to make a mistake.

VERY IMPORTANT: BE VERY CAREFUL CONNECTING A HACKED CIRCUIT TO A MIXER OR AMPLIFIER THAT GETS ITS POWER FROM THE WALL. IT'S BEST TO TEST FOR ANY POSSIBLE ELECTROCUTION HAZARD BY GINGERLY TAPPING THE CIRCUIT BOARD, JACKS, AND POTS WITH A DRY FINGER AND FEELING FOR ANY BUZZ OR TINGLE. ALTERNATIVELY, LET A SQUIRREL RUN ACROSS THE BOARD.

Figure 17.3
Homemade stereo isolation box made with output transformers removed from an API mixer, Nicolas Collins.



And always remember the 14th Rule of Hacking:

Rule #14: Kick me off if I stick (Zummo's rule).

Always have a buddy nearby when there is a risk of electrocution, and chant Peter Zummo's mantra before you power up.

An excellent insurance against electrocution is to insert a DI box between your circuit and the AC-powered world—one of these can be purchased from almost any retailer selling electric guitars, microphones, keyboards, etc. Or, hacking at a somewhat more advanced level, you can wire what is known as an "audio isolation transformer" between the circuit's output and the rest of your sound system (see Figure 17.3). But if you are unsure of your hacks or the power grid, JUST STAY AWAY FROM ANY OUTLETS! Use a telephone tap on the speaker instead, if you want to get loud.

BATTERY SUBSTITUTION

Almost all toys use batteries that put out either 9 volts or 1.5 volts. Most 9-volt batteries look the same: bricks with two connectors that resemble android navels (both innies and outies). However, 1.5-volt batteries come in all sorts of packages: cylindrical ones, like D cells (the biggest kind, in the flashlights of Southern sheriffs), C cells (a little smaller), AA cells ("penlight" flashlight batteries), and AAA cells (even thinner and a bit shorter, like some metric mismatch of an AA battery), and button cells (the watch and camera batteries that are infernally small, come in a zillion different sizes and shapes, and are way too expensive and hard to find). A few button cells put out 3 volts (inside the casing they stack 2 tiny batteries), and there are some oddball batteries (like the one that looks sort of like an AAA but puts out 12 volts, often used in remote controls for garage doors), but the vast majority of batteries follow the above rules.

Nine-volt batteries are usually used singly, but 1.5 volt are often combined to add up voltage to power a circuit—commonly one will find them in sets of two, three, or four. The larger (and heavier) the battery the more *current* it provides, which means it lasts longer and can power a larger circuit, so:

Rule #15: You can always substitute a larger 1.5-volt battery for a smaller one, just make sure you use the same number of batteries, in the same configuration.

This means you can replace those little button battery cells with the same number of AA cells and run the circuit much longer and much cheaper, and afterwards you can find replacement batteries almost anywhere. All you need to do is:

1. Disconnect the existing battery holder, noting which wire connects to the "+" end of the battery stack, and which connects to the "–" end (look at the labeling on the batteries or holder, or measure the voltage with a meter).
2. Get a battery holder for larger batteries of your choice.
3. Connect it to the circuit, observing the proper polarity of the wires you de-soldered earlier.

Some low-current 6-volt circuits (i.e., using four AA, AAA, or button cell batteries) will run on a 9-volt battery, and might even react to the additional juice with extra perkiness, but others will succumb to cardiac arrest. Unfortunately there's really no way to know until you try it, so proceed with caution (and a duplicate circuit, if at all possible) and disconnect the new battery if you smell smoke or feel a component on the circuit board getting hot.

As you accumulate circuits you will be tempted to minimize your energy costs by using a single battery (or set of batteries) to run several devices. This, unfortunately, is not always a good idea: sharing often induces noise, weird interference, and interaction, especially if you try to connect more than one of the circuits to the same amplifier.

Rule #16: It's always safer to use separate batteries for separate circuits.

How big a battery to upgrade to has as much to do with fitting them inside the device as any electrical consideration, which brings us to our next topic.

PACKAGING

As your first hack nears completion you'll want to think about how to package it. You have a few basic style choices:

Stealth: Keep the original packaging, with added knobs, switches, and jacks, as needed (see Figure 17.4 and 17.5).
Camp: Go for other recycled housing, such as a cigar box, a cereal box, or a human skull (see Figure 17.6 and 27.5 in Chapter 27). David Tudor favored plastic soap boxes. Since the rise of the DVD, plastic VHS boxes fill the dumpsters outside rental shops, and they make perfect homes for circuit boards (see Figure 26.8). Cigar boxes are great because they can usually be had for free, and you can open them easily to change batteries or touch the circuit (see Figure 11.2 in Chapter 11). If the clock speed is controlled by photoresistors inside the box, the pitch will glide up and down as you open and close the box, like a cubist trombone. Unfortunately, the

Figure 17.4 Stealth packaging: bent keyboard by Alex Inglizian.

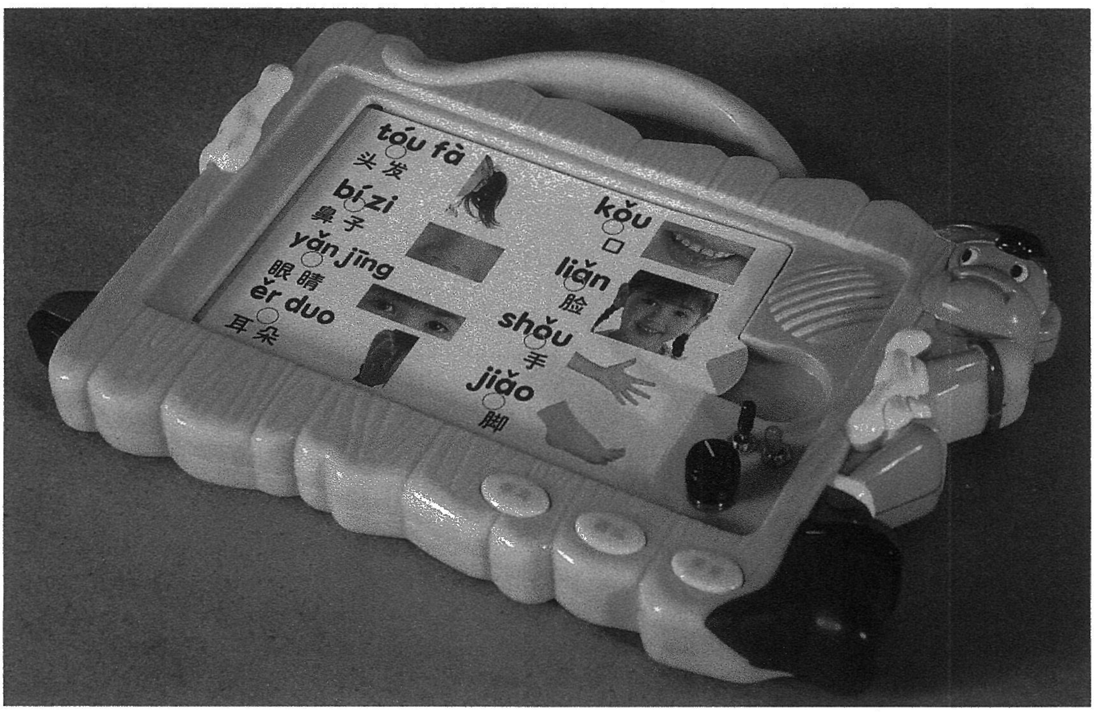
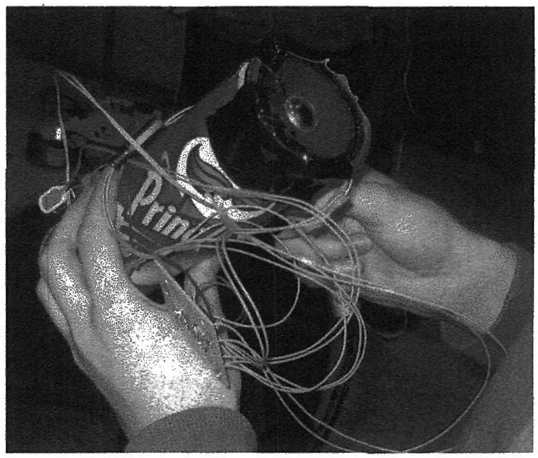


Figure 17.5 Stealth packaging: bent Chinese language trainer by Nicolas Collins.

Figure 17.6
Camp packaging: circuit inside Pringle tube by André Bosman.



wood of a cigar box is sometimes a little too thick for some jacks and pots to mount easily—you may need to countersink the mounting holes in order to secure any nuts that screw down; alternatively, you can pass shielded cable through holes in the wood and solder plugs or jacks directly to the ends, and end up with a cigar box octopus. Altoid tins are good for small circuits (they hold a 9-volt battery neatly), but since they are made of metal you must make sure the circuit does not short out against the case—the discrete application of electrical tape to the bottom of the circuit board or the inside of the tin should do the trick (a sheet of thin cardboard works too); one can also buy plastic "standoffs" for this purpose. You can see Altoid tins in action throughout this book, the legacy of my son's long-standing obsession with minty breath.

Sandwich: Two slabs of acrylic plastic or thin wood with a circuit board in between (see Figure 17.7). Fast to make, and clear plexi lets you see what's going on inside.

Traditional: One of those plastic or metal boxes from Radio Shack, or numerous online retailers, that make your product look "professional" (or boringly geeky, depending on your perspective; see Figure 17.8). Remember that a bare circuit board will short out if placed in a metal box unless it is isolated from the metal, as mentioned for the Altoid tin, above.

The decision is partly topological (how do I fit in the all new jacks, pots, and switches?), partly practical (what's the easiest material to drill?), but largely aesthetic (what looks coolest?).

Now that your first hack is resting comfortably in a beautiful box, the time has come to show it off. Get out of the shop, pick up the phone and book that gig! Or at least upload something to YouTube.

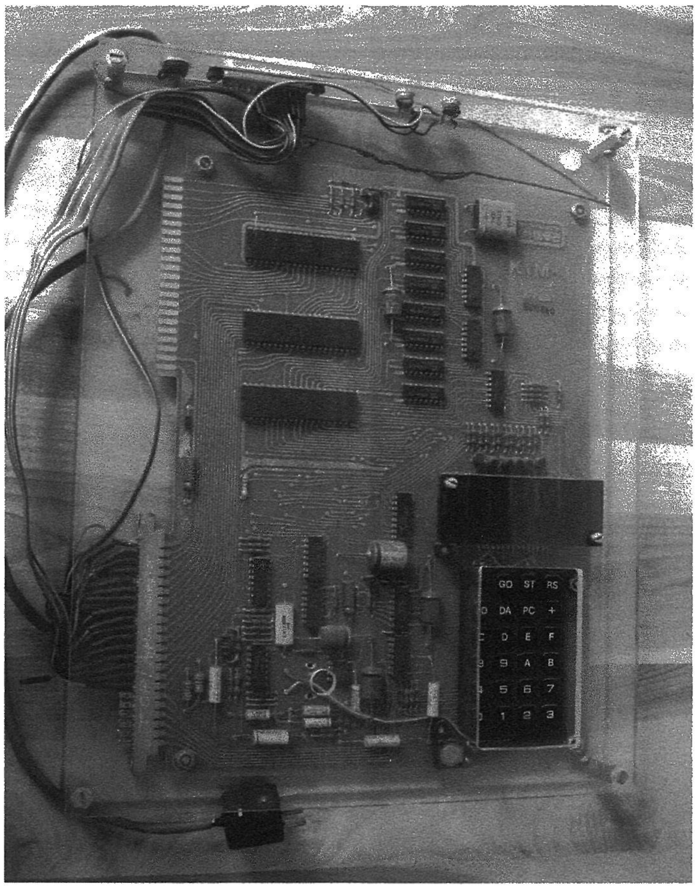


Figure 17.7
Sandwich packaging: David Behrman's "Kim 1" microcomputer (1977).

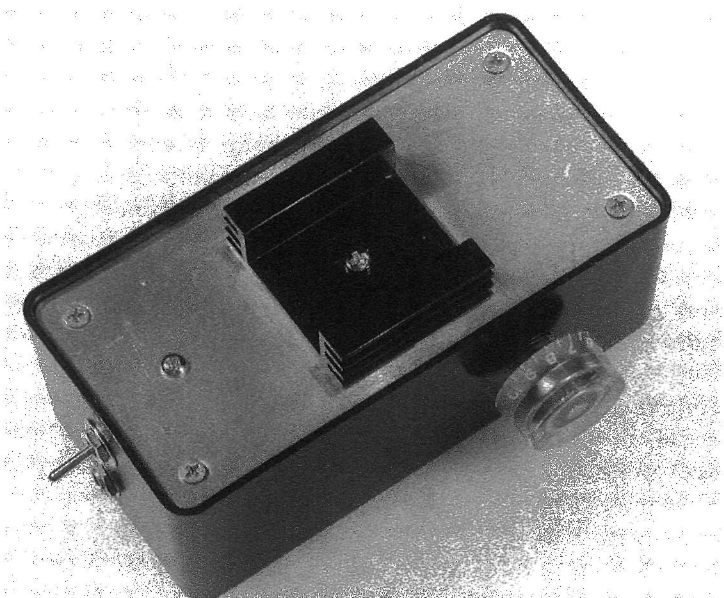


Figure 17.8
Traditional boring packaging: small amplifier by Nicolas Collins.

PART IV

Building